Watershed distribution equipment infrared thermal image segmentation method based on the morphological marker

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Abstract. In the process of infrared thermal image segmentation of distribution equipment, efficiency of the segmentation is low; it is easy to appear the over-segmentation phenomenon and cannot better segment the anomaly region of infrared thermal. To solve this problem, starting from the basic principle of the watershed algorithm, an improved watershed algorithm based on morphological marker was proposed. Firstly, the algorithm operate morphological gradient for image to be segmented. Then it extracts the region minimum by using H-minima transform and use minima imposition technology to remark the gradient image. In the end, the marked gradient image was segmented by watershed algorithm. According to the experimental verification of MATLAB, this improved segmentation method has higher feasibility and can successfully extract anomaly region of the infrared thermal image.

Introduction

In recent years, with the increasing use of infrared thermal imager in the temperature monitoring of power equipment, a higher requirement is put forward for the infrared image processing technology. Infrared image segmentation is one of the effective methods of infrared image processing. However, it has the characteristics of low resolution, large noise, and relatively fuzzy. When using the traditional image segmentation method to segment them, the results are not good enough. The segmentation method based on the threshold and based on edge detection are common infrared image segmentation method [1-3]. Among them, the segmentation method based on the threshold cannot reflect the infrared image gray distribution in space, and can only get the range of pixel gray value change of infrared image. The segmentation method based on edge detection is according to the different characteristics of the two sides of the edge. It segments the image mainly through to detect image’s discontinuity of the local characteristics and connect the edge points into the boundary. Compared to other algorithms, watershed algorithm has faster running speed, more accurate positioning, and better sealing ability of target image contour and can sensitively response to changes in pixels. Nevertheless, it will inevitably arise over-segmentation problem. This paper proposes an improved watershed algorithm based on morphological marker. Starting from the basic principle of the watershed algorithm, firstly, the algorithm operate morphological gradient for image to be segmented. Then it extracts the region minimum by using H-minima transform and use minima imposition technology to remark the gradient image. In the end, the marked gradient image was segmented by watershed algorithm. According to the experimental verification, this improved segmentation method has higher feasibility and can successfully extract anomaly region of the infrared thermal image.

Watershed segmentation method

The watershed segmentation method [4] draw on the geography knowledge, in which the terrain height of geography is applied to the pixel gray value of the image. It uses simulation process of soaking to conduct watershed segmentation.

The catchment basin is a key part of the watershed method; it can reflect the local minimum near the area. In the simulation process of soaking, the water levels will rising in the basin, and then blocked by the watershed, to ensure different catchment basins of water will not affect each other. When the simulated water immersion process is finish, the formation of the final watershed because the segmented image includes the target area and the background area. The grayscale change of internal, background regions of the target area are relatively little, while the change of grayscale value of the edge of the target area, and the background area is large. Therefore, it can be said that the region whose grayscale value is relatively uniform of the gradient image is the local minimum value region, and the edge region is corresponding to the watershed. After the watershed connection, you can get the final segmentation image.

The operation speed of watershed segmentation algorithm is fast. The segmented object has a complete boundary, and the weak edge of object can be detected. Due to image noise and other factors, the gradient image will have pseudo local minimum areas, leading to over segmentation. Through the research, people found a way to prevent over segmentation phenomenon. This method is to using the gradient amplitude to process the target image and then using some other knowledge to add a preprocessing stage; this knowledge was integrated into the whole process of image segmentation. The number of regions after image segmentation were strictly controlled to prevent over segmentation phenomenon .Among these knowledge, the best used and the most widely used is the method based on the theory of marker [5] [6]. After integrating the theory of marker, we hope to have a set of internal and external markers, and then use these markers to modify the gradient image obtained in order to obtain better segmentation effect.

Institutions Optimization Design

This paper adopted a kind of improved watershed algorithm based on morphological markers [7], the specific algorithm process is shown in Figure 1.

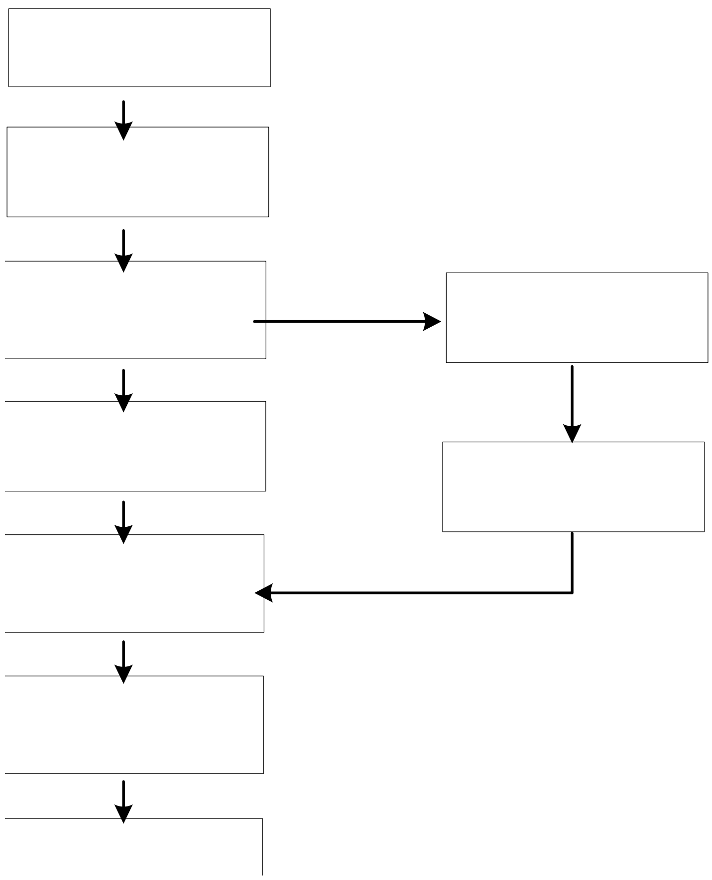


Fig.1. The flow chart of watershed segmentation method based on morphological marker

(1) morphological gradient

Morphological gradient is a method to determine whether there is a contour edge by detecting the gradient of a certain point in the target image.

In the morphological gradient structure element b is used for dilation and erosion of target image *f*（*x,y*）to get local maxima and local minimum value of *f*, so we use digital differential defined gradient to the corresponding, the morphological gradient image *g(x,y)*can be expressed as a formula (1):

$$g(x,y) = f(x,y) \oplus b(x,y) - f(x,y) \Theta b(x,y) \tag{1}$$

In the formula $\oplus$ indicate the dilation of morphology, Θ indicate the erosion of morphology and $b(x,y)$ indicate the elements of the disc shape. The morphological gradient and threshold method are generally used together in order to improve the quality of edge detection.

(2) morphological reconstruction

With regard to morphological gradient image, it is not possible to remove the noise very thoroughly, and the image still contains noise. Therefore, we need to use a new image processing technology: morphological reconstruction. Morphological reconstruction refers to morphological open reconstruction and morphological close reconstruction, the noise of the target image and the pixels point without structural elements will be eliminated by the open and close reconstruction together.

Morphological open and close reconstruction operations are formed by the combination of morphological dilation and erosion. With regard to Morphological gradient image *g(x,y)* and reference image *p(x,y)* and structural element *b*, morphological dilation can be defined as eq. (2):

$$\begin{cases} D_b^{(1)}(g,p) = (g \oplus b) \wedge p \\ D_b^{(n+1)}(g,p) = (D_b^{(n)} \oplus b) \wedge p, n = 1,2\cdots \end{cases} \tag{2}$$

Among them, *b* is disc shape structure element, $\wedge$ indicates that the minimum value is obtained point by point, and the morphological dilation is an iterative operation. When the number of iterations reaches the preset value or $D_b^{(n+1)} = D_b^n$, the operation suspension. Therefore, morphological open reconstruction $R_b^{(rec)}$ is defined as the formula (3):

$$R_b^{(rec)}(g,p) = D_b^{(rec)}[(g \oplus b), p] \tag{3}$$

$D_b^{(rec)}$ indicate the result of the convergence of geodesic dilation. Morphological open and close reconstruction is mutually dual. Therefore, morphological erosion and close reconstruction can be defined as formula (4), (5):

$$\begin{cases} E_b^{(1)}(g,p) = (g \Theta b) \vee p \\ E_b^{(n+1)}(g,p) = (E_b^{(n)} \oplus b) \vee p, n = 1,2,\cdots \end{cases} \tag{4}$$

$$C_b^{(rec)}(g,p) = E_b^{(rec)}[(g \oplus b), p] \tag{5}$$

Among them, $\vee$ indicates that the maximum value is obtained point by point, $E_b^{(rec)}$ indicates the result of morphological erosion. Therefore, morphological reconstruction is defined as the formula (6):

$$g_b^{(rec)} = C_b^{(rec)}[R_b^{rec}(g,p), p] \tag{6}$$

(3) Marker extraction

The noise can be reduced, but the pseudo minimum point cannot be avoided after morphological reconstruction. This paper use the *H-minima* proposed by Soille. The approach of the *H-minima* is that comparing with the image threshold H which is given to eliminate the minimum point of less than H in the local area, so that the number of the over segmentation regions can be greatly reduced. Therefore, it is very important to determine the value of H. If the H value is too small, it cannot play a significant role because the removal of the minimum points is relatively small. If the value is too large, there will be the phenomenon of under segmentation because the majority of the existence of the minimum point will be removed [8].

The selection of H value is usually determined by the prior knowledge, and there is no specific selection method. The average value of all the minima is used to correct the size of the value. The minimum value of ∇I is assumed to ∇I_{min}, hence

$$H = mean(\nabla I_{min}) \tag{7}$$

In the application of the extended minimum transform, Gaussian filter is adopted to obtain low frequency ∇I_{low}. The formula can be expressed as (8):

$$\nabla I_{mark} = H\,min(\nabla I_{low}, H) \tag{8}$$

Among them, H_{min} is the *H-minima*, and the binary mark image is ∇I_{mark}, which is the image after the extended minimum transform.

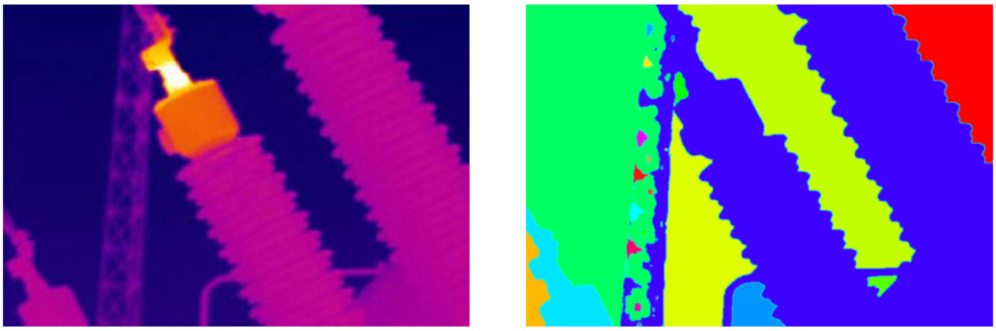
After extracting the minimum value through $H-minima$ transform, we can modificate of ∇I with minimal value mandatory labeling operations to get ∇I. The formula is expressed as:

$$\nabla I = I_m\,min(\nabla I, \nabla I_{mark}) \tag{9}$$

Finally, watershed segmentation was carried out to get infrared thermal image segmentation.

Experimental results and analysis

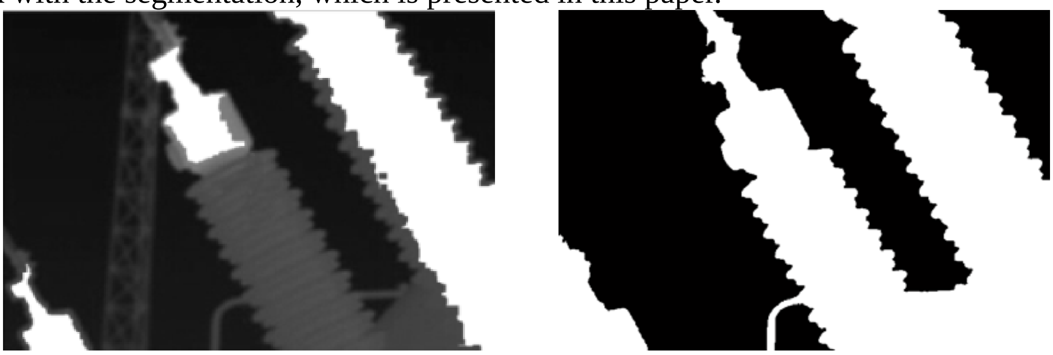
The following we analysis and compare the watershed segmentation algorithm with watershed segmentation algorithm based on morphological. Firstly, the traditional watershed segmentation is performed on the original infrared thermal image of the transformer bushing in the distribution. As shown in Figure 2(a), our segmentation target is thermal anomaly region. However, in Figure 2(b), there is a serious phenomenon of over segmentation.



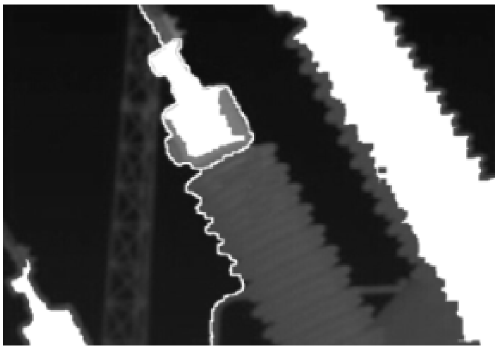
(a) (b)

Fig.2 the color map of the original image and the traditional watershed

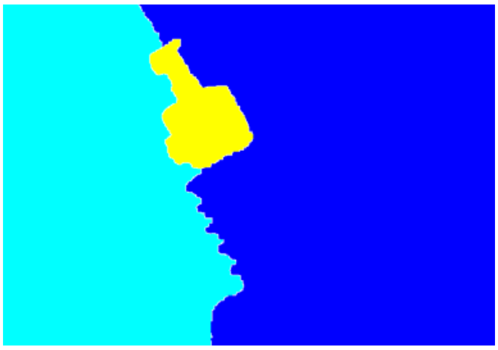
Then, the original infrared thermal image of the distribution transformer bushing is processed by the method of this paper. According to the segmentation step. As shown in Figure 3 (a), the maximum value of the adjusted area can be obtained in turn. As shown in Figure 3 (b), the morphological opening and closing of the reconstructed image. As shown in Figure 3 (c), the segmentation map with marking the boundary. As shown in Figure 3 (d), the segmentation map of color mark with the segmentation, which is presented in this paper.



(a) (b)



(c)



(d)

Fig.3.Watershed segmentation based on morphological marker

Can be seen from Figure 3, the over segmentation phenomenon of infrared image of distribution transformer bushing significantly reduced by the use of watershed algorithm based on morphological marker .The areas number of conventional watershed segmentation is 24, but the number is 3 now. The contour of the target area in the image is more clearly, which can effectively reduce the number of the watershed transform.

Conclusion

This paper proposes an improved watershed algorithm based on morphological marker. Starting from the basic principle of the watershed algorithm, firstly, the algorithm operate morphological gradient for image to be segmented. Then it extracts the region minimum by using H-minima transform and use minima imposition technology to remark the gradient image. In the end, the marked gradient image was segmented by watershed algorithm. The over segmentation phenomenon of infrared image of distribution transformer bushing significantly reduced by the use of watershed algorithm based on morphological marker .The segmented regions from 24 reduced to 3. It is proved that this method is feasible, and the thermal anomaly area of the image is extracted.

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